ENGINEERING TOMORROW

Environmental **Product Declaration**

Turbocor® compressor TTH375

EPD issued	17.5.2023
EPD expires	17.5.2028
EPD author	Danfoss Climate Solutions
EPD type	Cradle-to-grave
Declared unit	One product over its Reference Service Life
Products included	Turbocor compressor TTH (199B0601)
Manufacturing Location	Tallahassee, USA
Use Location	France
Application	Air-cooled chillers, heat pump or heat recovery, thermal storage or process applications
Mass	153,07 kg without packaging 168,57 kg with packaging
Dimensions (H×W×D)	932 mm (36.7in) – 590 mm (23.2 in) – 487 mm (19.2 in)
Verification	[ ] External [X] Internal [ ] None
Produced to	Danfoss Product Category Rules (2022-09)
Internal independent verifier	Danfoss Power Electronics & Drives A/S

DISCLAIMER
This EPD was prepared to the best of knowledge of Danfoss A/S. The life cycle assessment calculations were performed in accordance with ISO 14040 & 14044 and EN15804+A2.
All results were internally reviewed by independent experts. While this declaration has followed the guidance of ISO 14025, it has not been externally verified or registered by an EPD programme and therefore does not fully comply with the ISO 14025 standard.
This EPD has been published by Danfoss A/S on Danfoss Product Store and Danfoss Website. For questions, feedback or requests please contact your Danfoss sales representative.

Introduction

This Environmental Product Declaration (EPD) follows the Danfoss Product Category Rules (PCR) (2022-09-20). These rules provide a consistent framework for calculating and reporting the environmental performance of Danfoss' products and is aligned with relevant international standards, particularly ISO 14025:2006, EN 15804+A2:2019 and EN 50598-3:2015.

This document has been produced by Danfoss A/S following an internal verification process, but it is not a third-party verified document.

What is an EPD?

An EPD is a document used to communicate transparently, the quantified environmental impacts of a product over its lifecycle stages. This quantification is done by performing a Life Cycle Assessment (LCA) in line with a consistent set of rules known as a PCR (Product Category Rules).

An EPD provides:

- A product's carbon footprint together with other relevant environmental indicators, including air pollution, water use, energy consumption and waste, over its own life cycle (Modules A-C), as well as the expected benefits of reuse and recycling in reducing the impact of future products (Module D). See Table 1 for module descriptions.
- Environmental data allowing customers to calculate LCAs and produce EPDs for their own products.

Type of EPD

This EPD is of the type 'cradle-to-grave' and includes all relevant modules: production (A1-A3), shipping (A4) and installation (A5); operational energy use (B6); deconstruction (C1), waste collection and transport (C2), treatment (C3) and disposal (C4). It also includes potential net benefits to future products from recycling or reusing post-consumer waste (D). The codes in brackets are the module labels from EN 15804+A2. Modules concerning use, maintenance, repair, replacement, refurbishment (B1-B5) and operational water use (B7) are excluded, following the cut-off rules from EN 15804.

Table 1: Modules of the product's life cycle included in the EPD

Product stage			Installation		Use stage							End-of-life stage				Benefits
Raw materials	Transport	Manufacture	Transport	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-install.	Transport	Waste processing	Disposal	Benefits and loads outside system boundaries
A1	**A2**	**A3**	**A4**	**A5**	B1	B2	B3	B4	B5	**B6**	B7	**C1**	**C2**	**C3**	**C4**	**D**
X	**X**	**X**	**X**	**X**	MNR	MNR	MNR	MNR	MNR	**X**	MNR	**X**	**X**	**X**	**X**	**X**

(X = declared module; MNR = module not relevant)

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Overview of LCA study

The new Danfoss Turbocor® TTH compressors expands the benefits of oil-free technology into high lift applications with pressure ratios up to 6.2. High lift applications include air-cooled chillers in hot ambient climates, hot water for heat pump or heat recovery, and low-temps for thermal storage or low-temp process applications. The TTH model is compatible with R134a and low GWP non-flammable R513A. See more information on Turbocor.Danfoss.com.

Figure 1: Turbocor compressor TTH375

Reference Service Life

For the purpose of this EPD the reference service life (RSL) of the product is considered to be 20 years.

Intended market

The intended market of this study is France, and the baseline scenario involves the distribution, installation, and end-of-life in France. With regards to the use stage and the end-of-life stage, this EPD is not representative of regions other than France.

Table 2: Product composition

Material	Mass (kg)	(%)
Metals	135,04	88,22%
Plastics & Rubbers	6,96	4,54%
Natural materials	0,004	0,003%
Electrical/electronic	11,08	7,24%
Total material	153,07	100,00%
Packaging material	Mass (kg)	%
Total packaging	15,50	100,00%
Total material & packaging	Mass (kg)	%
Total material & packaging	168,57	100,00%

Data quality

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Overview of LCA study

Data quality of the selected datasets is generally assessed as good and very good in terms of geographical, time and technology representativeness and applicability. Background data is from GaBi database version 2022.

Allocation and cut-off criteria

The allocation is made in accordance with the provisions of EN 15804+A2. All major raw materials and all the essential energy are included. All hazardous materials and substances are considered in the inventory. Data sets within the system boundary are complete and fulfil the criteria for the exclusion of inputs and output criteria.

System boundaries

The results in this EPD are split into life cycle modules following EN 15804 (Figure 1): production (A1-A3), distribution (A4), use (B6) and the end of the product's life (C1-C4). Module D represents environmental benefits and loads that occur beyond the system boundary (i.e., in future products).

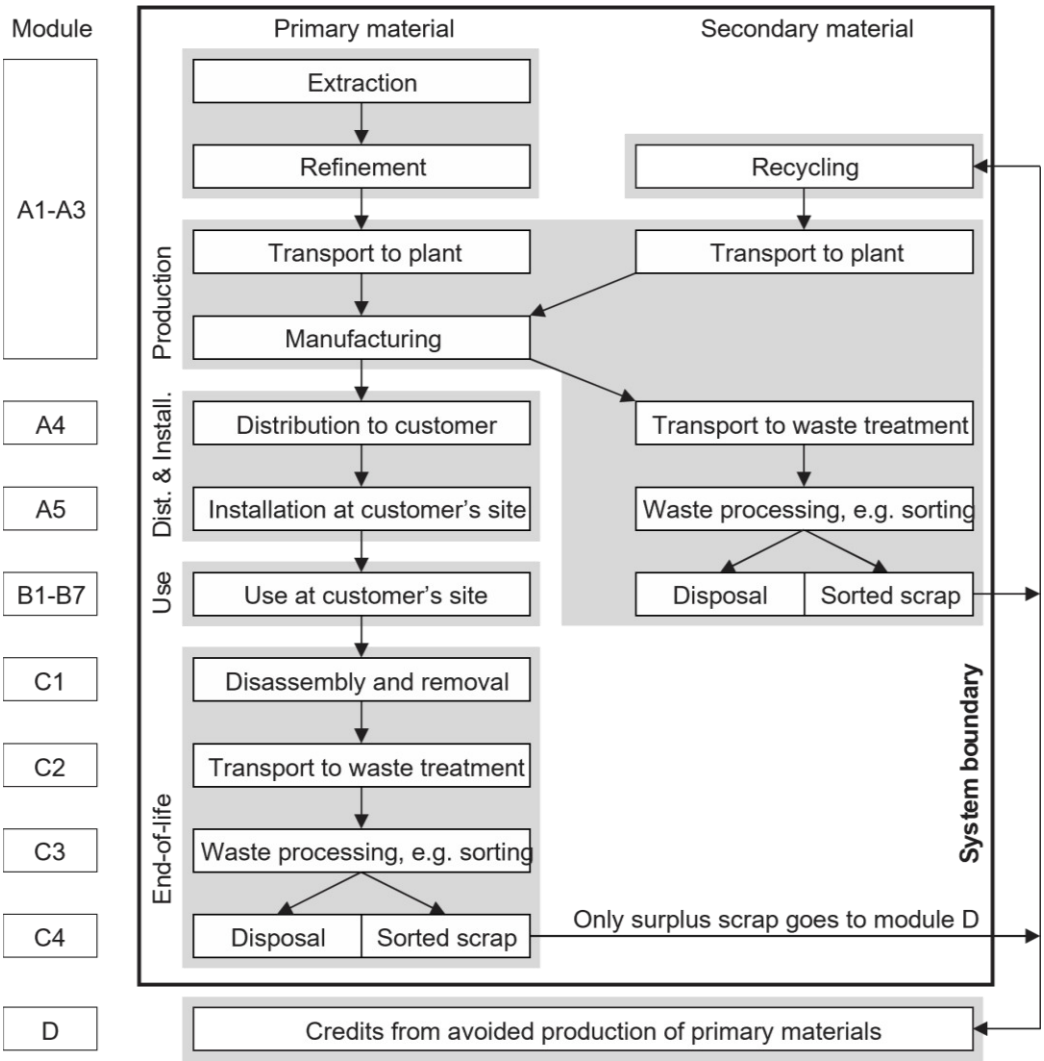

Figure 3: Modular structure used in this EPD (following EN 15804+A2)

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Overview of LCA study

Product and packaging manufacture (A1-A3)

Final manufacturing occurs in the Tallahassee plant, USA. In 2022 the consumed electricity for manufacturing was 67 % from solar power and 33 % from grid. The facility is certified according to ISO 9001:2015 and ISO 14001:2015. Where waste generated on-site is recyclable, it is separated and recycled. For further information, see here. The product is shipped in the packaging as described in Table 3. All packaging materials can be safely recycled or incinerated if appropriate local facilities are available.

Table 3: Biogenic carbon content in product and packaging

	Total (excluding recycling)
Biogenic carbon content in product [kg]	0,00189
Biogenic carbon content in accompanying packaging [kg]	0,00

Note: 1 kg biogenic carbon is equivalent to 44/12 kg of CO_2.

Shipping and installation (A4-A5)

This compressor is sold in France, a distance of 650 km by truck and 7.136 km by container boat was calculated based on the distance between the factory and the final customer market.

Module A5 includes disposal of packaging materials only. The product is assumed to be installed by hand. Energy use in handheld tools during installation is not included as it falls below the cut-off criteria in the Core Rules.

Use phase (B1-B6)

The Reference Service Life (RSL) applied in this EPD is 20 years.

According to DCS Turbocor compressors applications expert the TTH375 compressors can be used in a variety of applications including such as an office building in an air-cooled chiller. The energy analysis considering AHRI IPLV ratings in this application would have a total annual energy consumption of 159,914 kWh per year. A TTH375 in a similar office building type with a water-cooled application has a total annual energy consumption of 125,482 kWh per year.

The scope of this study is targeted for the French market; therefore, the product under study is sold and used in France. Sales also occur outside of France, which is important to note considering the impact the electricity grid mix can have on the emissions in the use phase.

Table 4: CO2 emissions per use phase location

Location of use	Use phase, kgCO2eq
France (Baseline scenario)	2,24E05

The major limitation of the impact calculations for the use phase is that the electricity grid mix in use is assumed to remain at the same carbon intensity over time. Following the plans for the decarbonization

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of the grid across France, the environmental impacts are expected to decrease over time within the course of the next 20 years. However, as decarbonization will occur in the future and as the pace of decarbonization is uncertain, the use of the emission intensity of today's grid should prove to be a "worst-case", conservative assumption.

End-of-life (C1-C4)

The standard end-of-life procedure from EN 50598-3 has been applied:

- Manual dismantling is used to separate recyclable bulk materials, e.g. bulk metals and plastics.
- Shredding is used for the remaining parts, such as printed circuit board assemblies.
- Ferrous metals, non-ferrous metals and bulk plastics are recovered through recycling.
- The remaining materials go to either energy recovery or landfill.

In line with EN 15804+A2, only the 'net scrap' (i.e., the leftover recyclable materials remaining after inputs of recycled content required in the manufacturing phase are first satisfied) is used to calculate the benefits and loads beyond the system boundary (Module D).

Two scenarios are examined for the end-of-life.

1. Recycling scenario with 100% of the product sent to recycling at the end-of-life, excluding fractions that cannot be recycled or incinerated (e.g., glass reinforcing in glass-filled plastics) and are sent to landfill (C3.1, C4.1, D.1)

This scenario illustrates best case performance. It assumes a 100% collection rate and best available recycling technologies. Under this scenario electrical cables, and all metals, flat glass and unreinforced plastics found within the body and chassis of the product are recycled. Printed circuit board assemblies are incinerated, and the copper and precious metals (gold, silver, palladium, and platinum) are recycled.

2. Landfill scenario with 100% of the product sent to landfill (C3.2, C4.2, D.2).

This scenario assumes that the whole product, including its packaging, is landfilled. It is designed to represent a poor end of-life-route where valuable resources are lost.

Benefits and loads beyond the system boundary (D)

Module D considers the net benefit of recycling (including energy recovery) of materials in the product and packaging, taking account of losses in the recycling process and the recycled material used in the production of the product. Module D covers the two end-of-life scenarios, as described above.

Environmental performance

This section presents the environmental performance of one-unit Turbocor compressor TTH375 **(**199B0601**)**. Figure 4 presents the environmental impact of the compressor across a number of environmental impact categories (following EN 15804+A2:2019) per life cycle stage, over its full 20-year life cycle, including Global Warming Potential.

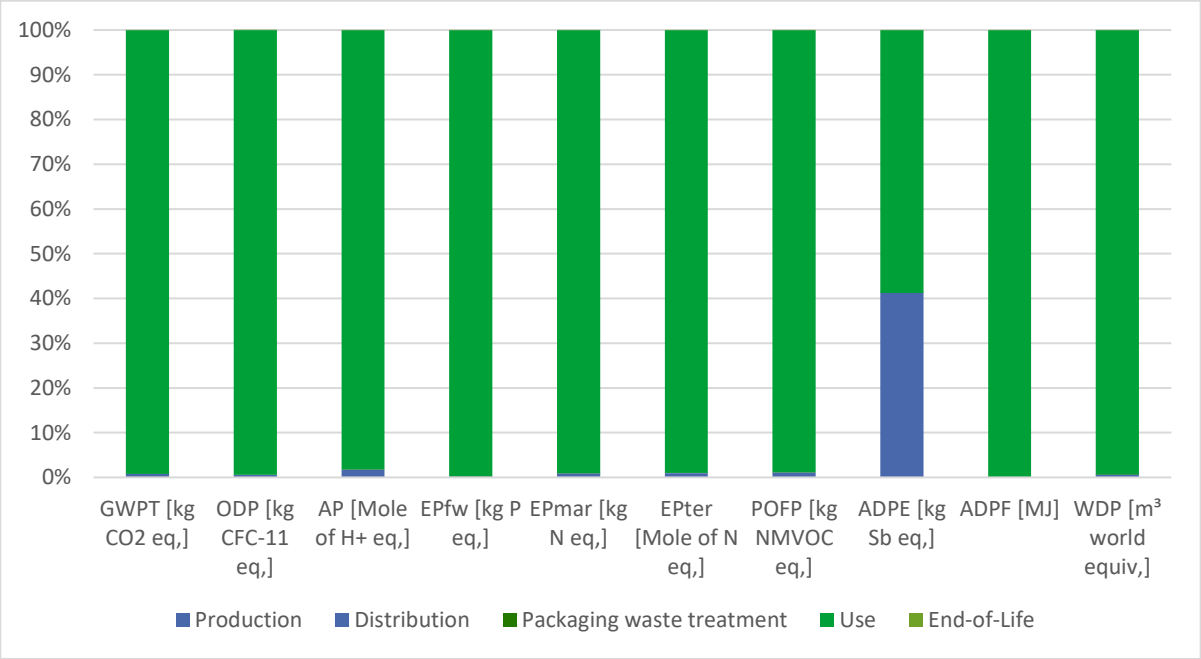

Figure 4: Breakdown of environmental impacts by life cycle stages (see Table 6 for descriptions of environmental impact indicators).

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Table 6: Environmental impact indicators

	Production	Distribution	Packaging waste treatment	Use	End-of-Life						(not included in Figure 4)	
Life cycle stages based on EN 15804+A2	**A1-A3**	**A4**	**A5**	**B6**	**C1**	**C2**	**C3.1** Recycling	**C3.2** Landfill	**C4.1** Recycling	**C4.2** Landfill	**D.1** Recycling	**D.2** Landfill
Description / **Environmental Impact Indicators**	Manufacture of the product from 'cradle-to-gate'	Transport of the product to the customer	Installation of the product and disposal of used packaging	Use of the product over its lifetime e.g., 20 years	Deinstallation of the product from the site	Transport of the product to waste treatment	Processing waste for recycling		Disposal of waste that cannot be recycled (through landfill and incineration)		Potential benefits and loads beyond the system boundary due to reuse, recycling, and energy recovery	
GWPT [kg CO2 eq.]	1,87E+03	2,23E+01	1,36E+00	2,36E+05	0,00E+00	1,35E+00	1,35E+01	0,00E+00	7,19E+00	3,98E+00	-8,03E+02	-5,16E+01
GWPF [kg CO2 eq.]	1,87E+03	2,22E+01	1,35E+00	2,33E+05	0,00E+00	1,35E+00	1,34E+01	0,00E+00	7,19E+00	3,98E+00	-8,02E+02	-5,16E+01
GWPB [kg CO2 eq.]	-6,62E-03	0,00E+00	6,62E-03	2,52E+03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
GWPLULUC [kg CO2 eq.]	9,76E-01	5,33E-02	9,25E-04	7,38E+01	0,00E+00	3,21E-05	9,05E-02	0,00E+00	7,93E-05	4,19E-03	-5,72E-01	-5,00E-03
ODP [kg CFC-11 eq.]	4,78E-08	1,60E-12	1,02E-13	8,02E-06	0,00E+00	1,55E-16	3,87E-12	0,00E+00	1,14E-12	5,66E-12	-5,61E-09	-4,63E-10
AP [Mole of H+ eq.]	1,03E+01	5,44E-01	7,58E-03	5,92E+02	0,00E+00	2,01E-03	8,15E-02	0,00E+00	2,35E-03	2,46E-02	-4,62E+00	-1,76E-01
EPfw [kg P eq.]	2,20E-03	3,14E-05	8,61E-06	1,09E+00	0,00E+00	2,87E-07	4,83E-05	0,00E+00	5,40E-07	9,57E-05	-5,48E-04	8,88E-07
EPmar [kg N eq.]	1,48E+00	1,46E-01	3,86E-03	1,77E+02	0,00E+00	8,18E-04	3,97E-02	0,00E+00	1,02E-03	8,16E-03	-4,70E-01	-2,43E-02
EPter [Mole of N eq.]	1,62E+01	1,60E+00	4,23E-02	1,73E+03	0,00E+00	9,03E-03	4,40E-01	0,00E+00	1,23E-02	8,96E-02	-5,05E+00	-2,64E-01
POFP [kg NMVOC eq.]	4,68E+00	4,04E-01	7,18E-03	4,36E+02	0,00E+00	1,90E-03	7,53E-02	0,00E+00	2,56E-03	2,03E-02	-1,54E+00	-8,64E-02
ADPE [kg Sb eq.]	1,01E-01	1,32E-06	4,39E-07	1,44E-01	0,00E+00	4,73E-08	1,40E-06	0,00E+00	2,39E-08	3,00E-07	-9,17E-02	1,54E-03
ADPF [MJ]	2,59E+04	2,78E+02	1,77E+01	2,34E+07	0,00E+00	1,92E+01	1,84E+02	0,00E+00	3,67E+00	5,41E+01	-1,21E+04	-1,23E+03
WDP [m^3 world equiv.]	5,84E+02	1,14E-01	1,03E-01	9,41E+04	0,00E+00	2,24E-03	1,80E-01	0,00E+00	9,14E-01	2,30E-01	-1,14E+02	-2,85E+00

How to read scientific numbers:

e.g. 2,05E02 = 2,05 x 10^2 = 205

2,04E-01 = 2,04 x 10^{-1} = 0,204

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Table 7: Environmental impact indicator descriptions

Acronym	Unit	Indicator
GWPT	kg CO_2 eq.	Carbon footprint (Global Warming Potential) – total
GWPF	kg CO_2 eq.	Carbon footprint (Global Warming Potential) – fossil
GWPB	kg CO_2 eq.	Carbon footprint (Global Warming Potential) – biogenic
GWPLULUC	kg CO_2 eq.	Carbon footprint (Global Warming Potential) – land use and land use change
ODP	kg CFC-11 eq.	Depletion potential of the stratospheric ozone layer
AP	Mole H+ eq.	Acidification potential
EPfw	kg P eq.	Eutrophication potential – aquatic freshwater
EPmar	kg N eq.	Eutrophication potential – aquatic marine
EPter	Mole of N eq.	Eutrophication potential – terrestrial
POFP	kg NMVOC eq.	Summer smog (photochemical ozone formation potential)
ADPE*	kg Sb eq.	Depletion of abiotic resources – minerals and metals
ADPF*	MJ	Depletion of abiotic resources – fossil fuels
WDP*	m^3 world eq.	Water deprivation potential (deprivation-weighted water consumption)

Results for module A1-A3 are specific to the product. All results from module A4 onwards should be considered as scenarios that represent one possible outcome. The true environmental performance of the product will depend on actual use.

The results in this section are relative expressions only and do not predict actual impacts, the exceeding of thresholds, safety margins, or risks. EPDs from others may not be comparable.

Carbon footprint

The carbon footprint (GWPF), cradle-to-grave, of the product is 2,35E05 kg CO2-eq (A1-C4), based on the average use phase scenario. The carbon footprint (GWPF) of production of this product, cradle-to-gate, is 1,87E03 kg CO2-eq (A1-A3).

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Table 8: Resource use

	A1-A3	A4	A5	B6	C1	C2	C3.1 Recycling	C3.2 Landfill	C4.1 Recycling	C4.2 Landfill	D.1 Recycling	D.2 Landfill
PERE [MJ]	1,64E+04	7,86E+00	7,82E-01	5,82E+06	0,00E+00	6,31E-02	1,41E+01	0,00E+00	6,61E-01	4,82E+00	-4,74E+03	-3,72E+02
PERM [MJ]	6,30E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERT [MJ]	1,64E+04	7,86E+00	7,82E-01	5,82E+06	0,00E+00	6,31E-02	1,41E+01	0,00E+00	6,61E-01	4,82E+00	-4,74E+03	-3,72E+02
PENRE [MJ]	2,57E+04	2,79E+02	1,90E+01	2,34E+07	0,00E+00	1,92E+01	1,84E+02	0,00E+00	3,67E+00	5,42E+01	-1,21E+04	-1,23E+03
PENRM [MJ]	2,33E+02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT [MJ]	2,59E+04	2,79E+02	1,90E+01	2,34E+07	0,00E+00	1,92E+01	1,84E+02	0,00E+00	3,67E+00	5,42E+01	-1,21E+04	-1,23E+03
SM [kg]	8,34E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF [MJ]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF [MJ]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
FW [m3]	2,44E+01	9,34E-03	3,33E-03	1,12E+04	0,00E+00	1,01E-04	1,77E-02	0,00E+00	2,15E-02	7,27E-03	-9,49E+00	-6,72E-01

Table 9: Resource use indicator descriptions

Acronym	Unit	Indicator
PERE	MJ	Use of renewable primary energy excluding renewable primary energy resources used as raw materials
PERM	MJ	Use of renewable primary energy resources used as raw materials
PERT	MJ	Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials)
PENRE	MJ	Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials
PENRM	MJ	Use of non-renewable primary energy resources used as raw materials
PENRT	MJ	Total use of non-renewable primary energy resources (primary energy and primary energy resources used as raw materials)
SM	kg	Use of secondary material
RSF	MJ	Use of renewable secondary fuels
NRSF	MJ	Use of non-renewable secondary fuels
FW	m^3	Net use of fresh water

Table 10: Waste categories and output flows

	A1-A3	A4	A5	B6	C1	C2	C3.1 Recycling	C3.2 Landfill	C4.1 Recycling	C4.2 Landfill	D.1 Recycling	D.2 Landfill
HWD [kg]	4,92E-05	1,26E-09	7,82E-11	5,79E-04	0,00E+00	1,32E-10	1,12E-09	0	2,63E-10	2,64E-09	-4,10E-03	-1,44E-05
NHWD [kg]	3,36E+02	3,34E-02	1,76E-03	7,63E+03	0,00E+00	1,92E-03	3,13E-02	0	2,47E+00	1,49E+02	-2,09E+02	-1,30E+01
RWD [kg]	1,25E+00	3,92E-04	4,49E-05	8,15E+03	0,00E+00	2,05E-05	2,92E-03	0	1,34E-04	4,17E-04	-1,02E+00	-8,45E-02
CRU [kg]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MFR [kg]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,44E+02	0,00E+00	0,00E+00	0,00E+00
MER [kg]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE [MJ]	1,24E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,23E+01	0,00E+00	0,00E+00	0,00E+00
EET [MJ]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,24E+01	0,00E+00	0,00E+00	0,00E+00

Table 11: Waste category and output flow descriptions

Acronym	Unit	Indicator
HWD	kg	Hazardous waste disposed
NHWD	kg	Non-hazardous waste disposed
RWD	kg	Radioactive waste disposed
CRU	kg	Components for reuse
MFR	kg	Materials for recycling
MER	kg	Materials for energy recovery
EEE	kg	Exported energy (electrical)
EET	kg	Exported energy (thermal)

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Table 12: Additional indicators*

	A1-A3	A4	A5	B6	C1	C2	C3.1 Recycling	C3.2 Landfill	C4.1 Recycling	C4.2 Landfill	D.1 Recycling	D.2 Landfill
PM [Disease incidences]	1,04E-04	9,14E-06	4,38E-08	5,06E-03	0,00E+00	1,07E-08	4,87E-07	0,00E+00	2,44E-08	2,45E-07	-5,97E-05	-2,97E-06
IRP [kBq U235 eq.]	1,99E+02	5,83E-02	3,81E-03	2,09E+06	0,00E+00	2,91E-03	7,13E-01	0,00E+00	2,06E-02	5,02E-02	-2,07E+02	-1,72E+01
ETPfw [CTUe]	1,51E+04	1,94E+02	1,43E+01	1,20E+07	0,00E+00	1,39E+01	1,29E+02	0,00E+00	2,65E+00	4,71E+02	-6,17E+03	-5,85E+02
HTPc [CTUh]	1,57E-05	3,76E-09	2,28E-10	1,36E-04	0,00E+00	2,58E-10	2,63E-09	0,00E+00	2,01E-10	2,95E-09	-8,10E-07	-3,64E-09
HTPnc [CTUh]	2,76E-05	1,89E-07	9,49E-09	5,56E-03	0,00E+00	1,12E-08	1,60E-07	0,00E+00	1,40E-08	3,02E-07	-1,29E-05	-5,27E-07
SQP [Pt]	5,25E+03	4,43E+01	4,01E+00	2,34E+06	0,00E+00	4,90E-02	7,54E+01	0,00E+00	7,73E-01	6,34E+00	-1,62E+03	-1,60E+01

Table 13: Optional indicator descriptions

Acronym	Unit	Indicator
PM	Disease incidence	Potential incidence of disease due to particulate matter emissions
IRP**	kBq U235 eq.	Potential human exposure efficiency relative to U235
ETPfw*	CTUe	Potential Comparative Toxic Unit for ecosystems (fresh water)
HTPc*	CTUh	Potential Comparative Toxic Unit for humans (cancer)
HTPnc*	CTUh	Potential Comparative Toxic Unit for humans (non-cancer)
SQP*	Dimensionless	Potential soil quality index

**Disclaimer for ADPE, ADPF, WDP, ETPfw, HTPc, HTPnc, SQP:* The results of these environmental impact indicators shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.

***Disclaimer for ionizing radiation:* This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.

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